

SENSING AND CONTROL OF VALVE FLOW RATE

FIELD OF THE INVENTION

[0001] The present invention relates to gas furnaces and appliances and, more particularly, to controls for gas input to gas furnaces and appliances.

BACKGROUND OF THE INVENTION

[0002] In gas appliances and furnaces, diaphragms and/or solenoids are commonly used for controlling the level of gas flow through a gas valve to a burner. Flow-control solenoids typically are actuated by continuous signals from a low-voltage power source. For this reason and for other reasons, valve control via diaphragms and solenoids tends to be complex and costly. In gas fireplace units, gas flow control may be via a stepper-motor-controlled valve, which can vary gas flow without a diaphragm and is powered by intermittent low-voltage signals. Such valves can vary gas flow to vary fireplace flame, but cannot sense outlet flow rate or adjust outlet flow to a desired flow rate value.

SUMMARY OF THE INVENTION

[0003] The present invention, in one embodiment, is directed to a gas valve for controlling the flow of gas to a burner. The gas valve includes an actuator that controls the flow of gas through the valve. A stepper motor operates the actuator. A first temperature sensor senses temperature of gas entering the valve. A second temperature sensor senses temperature of gas leaving the

valve. A controller controls the stepper motor in response to the sensed temperatures.

[0004] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating various embodiments of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0006] FIG. 1 is a longitudinal cross-sectional view of a gas valve in accordance with one embodiment of the present invention;

[0007] FIG. 2 is a cross-sectional view of the valve embodiment shown in FIG. 1, taken along the plane of line 2-2 in FIG. 1;

[0008] FIG. 3 is a cross-sectional view of a floor of the valve embodiment shown in FIG. 1, taken along the plane of line 3-3 in FIG. 1;

[0009] FIG. 4A is a partial schematic diagram of an embodiment of a gas valve control system; and

[0010] FIG. 4B is continuous with FIG. 4A and is a partial schematic diagram of the embodiment of a gas valve control system shown in FIG. 4A.

DETAILED DESCRIPTION OF THE INVENTION

[0011] The following description of various embodiment(s) is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

[0012] A gas valve according to one embodiment of the present invention is indicated generally in FIG. 1 and FIG. 2 by reference number 10. The gas valve 10 is used, for example, to control gas flow to a burner in a gas appliance or gas furnace. The valve 10 has a body 14 fabricated, for example, of cast aluminum. The valve body 14 has a top plate 18, a bottom plate 22, two side plates 24, and an inlet plate 28 from which extends an inlet block 32. A gas inlet 36 extends through the inlet block 32 and opens into an inlet chamber 40 in the body 14. An outlet block 44 extends from an outlet plate 46 of the valve body 14. An outlet chamber 50 is fluidly connected with a gas outlet 54 extending through the outlet block 44.

[0013] A bracket 56 extends within the body 14 from the outlet plate 46. The bracket 56 is integral with a separator plate 60 that separates the inlet chamber 40 from the outlet chamber 50. The separator plate 60 has a central, generally circular opening 62 that fluidly connects the inlet and outlet chambers 40 and 50 when a poppet 64 operable by a linear actuator 66 is in an open position as further described below.

[0014] FIG. 3 is a plan view of the separator plate 60, taken along the plane of line 3-3 in FIG. 1. The opening 62 has a chamfered edge 66 against which the poppet 64 fits snugly when in a closed position as shown in FIG. 1.

Another opening 70 in the separator plate 60 opens into a passage 72 through the bracket 56 that fluidly connects the outlet chamber 50 with the gas outlet 54.

[0015] The poppet 64 is mounted on a lower end 74 of a poppet shaft 76. A key-shaped upper end 78 of the poppet shaft 76 is movably mounted in a vertical key-shaped channel 80 in an arm 82 of the bracket 56. The poppet shaft 76 can be driven up and/or down by a stepper motor 84 mounted on the top plate 18. Specifically, a threaded shaft end 86 of the motor 84 extends through the top plate 18 into a threaded sleeve 88 such that rotational movement of the motor 84 is translated into linear movement of the poppet shaft 76. The keyed shapes of the channel 80 and shaft end 78 keep the poppet shaft 76 from rotating while the shaft 76 is moved up or down. It is contemplated that in other embodiments, other linear actuating elements could be utilized to move the poppet shaft 76 up and/or down.

[0016] The poppet shaft 76 and poppet 64 are concentrically aligned with the opening 62. The poppet 64 has a top portion 90 fabricated, for example, of rubber, and a lower plate 92 fabricated, for example, of aluminum. The plate 92 is affixed to the lower end 74 of the poppet shaft 76 and supports and stabilizes the rubber portion 90 relative to the poppet shaft 76. The poppet 64 is shaped so as to fit snugly against the chamfered edge 66 of the opening 62 when the poppet 64 is in the closed position.

[0017] When the stepper motor 84 is activated to lower the poppet shaft 76, the poppet 64 is lowered from the closed position. When the poppet 64 is in an open position, gas can pass from the inlet chamber 40 through the

opening 62 into the outlet chamber 50, at a flow rate determined by how far the poppet 64 is lowered from the closed position. In the embodiment shown in FIG. 1, the poppet 64 is hemispherically shaped, although embodiments are contemplated wherein the poppet and/or opening between the chambers may have other shapes and/or contours.

[0018] An inlet temperature sensor 104, *e.g.*, a thermistor, is mounted in the inlet block 32 and connected to terminals 108 and 112. A lead 114 of the inlet thermistor 104 extends through a passage 116 into the gas inlet 36. An outlet temperature sensor 120, *e.g.*, a thermistor, is mounted in the outlet block 44 and connected to terminals 122 and 126. A lead 130 of the outlet thermistor 120 extends through a passage 132 into the gas outlet 54. The temperature sensors 104 and 120 are, for example, thermistors having part number 2322 626 23102, available from BC Components International B.V., Alpharetta, Georgia 30076. It is contemplated that, in other embodiments, other temperature-sensing devices, including but not limited to transistors and/or resistance temperature detectors, could be used to sense gas temperature(s) in the gas inlet and outlet. In other embodiments, temperature sensor 104 may be different from temperature sensor 120.

[0019] An embodiment of a control system for controlling gas flow through the valve 10 is indicated generally in FIGs. 4A and 4B by reference number 200. The controller 200 includes a half-wave rectifier circuit indicated generally by reference number 204, a processor power supply circuit indicated generally by reference number 208, and a processor 212, *e.g.*, an erasable

programmable read-only memory (EPROM) 68HC705P6A, available from Motorola, Inc., <http://www.motorola.com>. The stepper motor 84 is driven in forward and/or reverse directions via a pair of driver circuits 216 under control of the processor 212. The processor 212 controls a signal that indicates a number of angular steps through which the motor shaft 86 is to rotate and thereby drive the poppet shaft 76. Mechanical switches, indicated schematically by reference number 220, are used to provide manual test control for starting, stopping and/or changing direction of the stepper motor 84. The stepper motor 84 is, for example, a 1.8-degree, size 23 single-shaft hybrid motor available from Source Engineering Inc. of Santa Clara, California.

[0020] As shown in FIG. 4A, the inlet thermistor 104 is electrically connected between a terminal E4 and a grounded terminal E5. In the present exemplary embodiment, wherein the pins 108 and/or 112 (shown in FIG. 2) are insulated from ground, the terminal E5 provides grounding, for example, through the valve 10 aluminum casting. The inlet thermistor 104 receives a constant current supply of, for example, about 0.0001 ampere, a current sufficiently low to prevent the inlet thermistor 104 from self-heating. The outlet thermistor 120 is electrically connected between a terminal E3 and the ground E5. The outlet thermistor 120 receives a constant current supply of, for example, about 0.05 ampere, a current sufficiently high to allow the outlet thermistor 120 to self-heat to a predetermined level.

[0021] A resistor R26 is configured with the inlet thermistor 104 such that a voltage drop across the resistor R26 corresponds to a temperature sensed

by the inlet thermistor 104. A resistor R27 connected across the outlet thermistor 120 is configured with the outlet thermistor 120 such that a voltage drop across the resistor R27 corresponds to a temperature sensed by the outlet thermistor 120. Resistors R26 and R27 preferably have equal resistance, for example, 8.2 k Ω .

[0022] During operation of the gas valve 10, as gas enters the inlet 36, the inlet thermistor 104 senses temperature of the gas in the inlet 36. The temperature is signaled to the processor 212 via resistor R26. When the poppet 24 is in an open position, gas flows from the inlet chamber 40 to the outlet chamber 50 and through the outlet 54. The outlet thermistor 120 senses heat removed by gas flow at the outlet 54. The thermistor temperature is signaled to the processor 212 via resistor R27.

[0023] As gas flows through the valve 10, it tends to draw heat from the self-heated outlet thermistor 120. The amount of heat drawn by the gas from the thermistor 120 corresponds to a gas flow rate through the valve 10. The processor 212 periodically compares the temperature of the inlet thermistor 104 with the temperature of the outlet thermistor 120 and uses the temperatures to determine a gas flow rate through the valve 10. Based on the determined gas flow rate, the processor 212 signals the stepper motor 84 to operate the poppet 64 so as to adjust the flow rate through the valve 10 in accordance with a desired flow rate.

[0024] It can be appreciated that an embodiment of a gas valve that includes a stepper motor and differential thermistor flow sensing as described

above can provide universal single-stage, multi-stage and modulating gas flow control in a gas appliance or furnace. The above described gas valve is capable of sensing a gas flow rate, and of maintaining a selected outlet gas flow rate, for single-stage, multi-stage and/or modulated burner applications.

[0025] The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.